BADEGGI JOURNAL OF AGRICULTURAL RESEARCH AND ENVIRONMENT, 2019, 01(01), 119–126

NCRI Press

Available online: www.ncribjare.org
ISSN 2695-2122, e-ISSN: 2695-2114
DOI: https://doi.org/10.35849/BJARE201901015
Journal homepage:www.ncribjare.org

Research Article

Nutraceutical Benefits of Sesame: A Case for Increase in Utilization and Value Addition in Nigeria

Umar, M. I.[1], Yusuf, A. F.[1], Apuyor, B. O.[1], Kabaraini, M. A.[1] and Shehu, M.[2]
[1]National Cereals Research Institute, Badeggi, Nigeria
[2]Federal University of Technology, Minna, Nigeria
Corresponding Author E-mail:umarmohammediya@gmail.com

Abstract
Sesame seed is a proteinous oil seed with good nutritional profile and high levels of health-friendly fatty acids. With its wide array of bioactive phytochemicals,its oil and other productswhen consumed regularly can serve as a nutraceutical with numerous health promoting benefits including the prevention, control or cure of many diseases and metabolic disorders. Nigeria is a major world producer of sesame, the utilization of the crop for food purposes is still very low (below 10%) due to limited knowledge on its nutritional and nutraceutical or health benefits. Thus, this paper takes a look at some nutraceutical properties of sesame and the health benefits derivable from consuming sesame or its products

Keywords*:* Nutraceutical, Utilization, Diabetes, Sesame, Cancer

Introduction

Sesame (*Sesamu indicum L*) is a leguminous oil seed crop grown in tropical and temperate regions between latitudes 40^0N and 40^0S, mostly in the developing countries (Aboje, 2011). In West Africa, the crop is known as beniseed while in East Africa, it is sim-sim. According to Morris (2002), there were about 869 varieties and accessions of sesame at the Plant Genetic Resources Conservation Unit (PGRCU) of the U.S. Agricultural Department (USAD) with Turkey contributing the highest number of 163, followed by 154 from India, U.S 119 and Nigeria contributing only 4 accessions to the genetic pool.

Sesame Production in Nigeria

Sesame was introduced into Nigeria through Niger Agricultural Project Limited in 1964 (Misari, 1998). After the Second World War in 1945, the high demand for vegetable oils for the production of soap, pharmaceuticals and other items brought the importance of sesame or beniseed to the lime light. The colonial masters in their bid to source for alternative sources of oil, turned to their colonies including Nigeria, and that was what led to the setting up of the farm centers at Kabba (Kogi state), Mokwa (Niger) and Yandav in Benue state, to coordinate research and production of sesame and soybeans (Misari, 1998).Sesame production in Nigeria began in the middle belt between latitudes 10^0N and 6^0S. As at 2002, the major producing areas in order of total output were Nasarawa, Jigawa, Benue, Yobe, Kano, Kogi, Gombe and Plateau states.In the year 2002, the Federal Government of Nigeria (FGN) in collaboration with the United States Agency for International Aid (USAID), under the auspices of the Rural and Agricultural Incomes in a Suitable Environment (RAISE) recognized and recommended sesame as one of the crops with greatest potentials for both sustainable export and local industrial growth, at least in the area of oil production (Chemonics, 2002).The following years witnessed steady and rapid increase in sesame production in the country, mainly by small holder farmers that do not enter into formal trade.

Date Received 08/08/18, Revised 16/01/19, Accepted 24/02/19 and Published 28/03/19

However, according to the Food and Agricultural Organization (FAO) estimates, Nigeria was ranked the 7th largest world producer of sesame seeds in 2010 with a total annual output of about 0.12 million metric tons and average yield of about 0.38 tons per hectare (FAOSTAT, 2013). According to the National Agricultural Extension Research and Liaison Services (NAERLS, 2010) sesame production has recently spread to about 26 states of the federation as a major crop, thus making Nigeria the second largest producer in Africa with an estimated annual output of over 300,000 tonnes (Agro Nigeria, 2016). Other major world producers of sesame are shown in Table 1.

Nutrient and Mineral Compositions of Sesame Seeds

The nutrient or chemical composition of any food substance depends on factors such as variety, soil conditions, ecology, photoperiod, date of planting, storage conditions and even the methods and equipment or standards used for the analysis (Ihekeronye and Ngoddy, 1985; Okaka *et al.*, 2014). In the case of sesame, the composition of the seeds also depends on seed characteristics such as size, colour, shape and texture (Shaidi, 2005). Thus, various values have been reported by different investigators as shown in Table 2.

The report by Shaidi (2005), obtained by analyzing one variety of sesame from Nigeria, a range of 17-32% protein content was obtained. It is rich in essential amino acid especially the Sulphur, also containing methionine and Cystein which are regarded as limiting amino acids of legumes (Hedge, 2012). Table 3 shows the amino acid composition of sesame seeds and the daily recommended requirements for an adult of 70kg weight by the World Health Organization (WHO, 2010).The carbohydrate content of sesame seeds ranges from 10.10-17.90% which is not only low but has low glycemic index (G.I) as expected of a legume (Svierpiper *et al*., 2009). Sesame oil has 80% polyunsaturated fatty acids (PUFAs) that are highly resistant to oxidation and polymerization by free radical mechanism that leads to rancidity. This stability has been attributed to the presence of some phytochemicals with antioxidative properties which include vitamin E and other tocopherols (Guillen and Goiceochea, 2008; Nagendra *et al*., 2012). Sesame fibre content is up to 9.4% (Nzikou *et al*., 2009), consisting of all the three classes of fibre, namely resistant starch insoluble and soluble fibres (Bazzano, 2008). Sesame seeds is also a good source of wide range of minerals which constitutes up to 17% of the dry weight and include calcium, phosphorus, iron, magnesium, sodium, manganese and zinc (Adenuga *et al*., 2012; Hedge, 2012). Apart from the basic nutrients, sesame seeds contain a lot of phytochemicals most of which are bioactive, and include vitamins, phytosterols, lignans, tocopherols, polyphenols and unique antioxidants. Many of these substances are secondary metabolites produced by the plants to protect themself from infections (Senior, 1996). Sesame seeds contain high levels (830-1010Mg/kg of oil) of vitamin E and other tocopherols (Shaidi, 2005) which are strong anti-oxidants.The antioxidants have the ability of delaying or inhibiting oxidative processes even when present in low levels (10-100ppm) (Borges *et al*., 1999). Antioxidants exert their effect by increasing the activation energy of the reaction thereby prolonging the "lifetime" of the substrate. This can be accomplished by decreasing the concentration of localized oxygen thereby preventing oxidation or preventing the initiation reaction through scavenging of free radicals. Other anti-oxidative mechanism includes binding of transitional metallic ions such as Fe^{2+} Fe^{3+} and Cu^{2+}, decomposing of peroxides to prevent their conversion to other reactive species and reacting with chain-propagating radicals to prevent hydrogen extraction from fatty acids (Bailey, 1996; Borges *et al*., 1999). The superior stability to oxidation and peroxidation of sesame oil has also been attributed to the presence of lignans, the major ones being sesamin (2.45mg/g seed) and sesamolin (1.10mg/g seed) (Kamal-Eldin *et al*., 2011). Other vitamins found in appreciable amounts in sesame include niacin (4.4-8.7mg/100g) folic acid (184mg/100g and pantothenic acid (0.6mk/100g) (Kamal-Eldin *et al*., 2011).

Properties of Nutraceuticals

The word nutraceutical was first coined and used by Stephen L de Felice in 1989, who defined it as a food or part of food that provides medical or health benefits including the prevention and treatment of diseases (Mannon, 1998; Kanu, *et al*., 2010). A nutraceutical must satisfy 3 basic requirements which include existing in its natural

form (not a tablet, capsule or powder), consumed on daily basis and it should be able to regulate biological processes with the hope of preventing, controlling or curing diseases (Kanu *et al.*, 2010).One major advantage of a nutraceutical over conventional drugs or medication is that it takes about 10 years and costs as high as 250 million dollars to develop, register and market a new drug while an unlicensed nutraceutical may take just a small fraction of this (Brower, 1998). A five-year study (1991-1995) on the side effects of nutraceuticals in the toxicology unit of Guy Hospital in London, concluded that the overall risk factor of these products was low, hence they are generally safe for use (Senior, 1996).

Nutraceutical Benefits of Sesame

Sesame or its oil contains as high as 1.19% phytostrerols and is considered one of the richest sources of sterols in the plant kingdom (Shaidi, 2005). The presence of these phytochemicals and others such as lignans, tocopherols and vitamins that are all bioactives, rightly confers on sesame the status of a nutraceutical when consumed on daily basis. Sesame has been regarded as one of the healthiest food substances in the plant kingdom (Niti*et al*., 2014), with more than 4 dozens of therapeutic applications or health benefits (Sanker *et al*., 2011). Despite the numerous health benefits of sesame, its utilization in Nigeria is below 10% (NAERLS, 2010) and limited to such uses as soup thickener and production of local snacks called "Kantu" in North Central states of Nigeria (Kogi and Benue). The low level utilization of sesame in Nigeria could be attributed to lack of awareness on the health benefits of the crop even among educated Nigerians. Therefore, this paper intends to highlight on some health benefits of sesame or its by-products when used on daily basis as a nutraceutical. This is aimed at creating awareness that will lead to increase in consumption of seeds and production of sesame in Nigeria.

Prevention and Control of Hypertension (BP)

The World Health Organization (WHO) reported increase in cases of high blood pressure or hypertension from 594 million in 1975 to 1.13 billion in 2015, mostly in poor developing countries (WHO, 2017). Hypertension occurs when the ratio of systolic to diastolic blood pressure is equal or greater than 140/90mmHg (normal blood pressure is 120/80 mmHg). High blood pressure is associated with high intakes of saturated fatty acids (FAs), trans- polyunsaturated fatty acids (PUFAs) and low density lipoprotein-cholesterol (LDL-Cholesterol, also called bad cholesterol). The linear conformation of these FAs favors close alignment and packaging of the molecules along the wall of the blood vessels, therefore causing blockage. This silent and gradual process progresses with time into atherosclerosis (narrowing and hardening of the blood vessels), hence a stronger pumping force or higher pressure is required (Sanker *et al*., 2011). Sesame seeds contain about 50% oil of which 80% exists as cis- PUFAs. The stereochemistry does not allow the close alignment and packing associated with the trans isomers, hence no blockage nor atherosclerosis (Gautham *and* Mohammed, 2009). Sesamin in sesame seeds or oil has been reported to have vasodilatory effects, hence can expand the blood vessels thereby lowering the blood pressure (Gautham *and* Mohammed, 2009, Kanu *et al.*, 2010, Niti *et al*., 2014). This vasodilatory property and dissolution of blood clot is reported for Magnesium which occurs in high level in sesame. This effect of sesamin and Magnesium has been explained in terms of their ability to decrease the thickness of the arterial walls and degenerate the fibrinoid in the walls (Niti *et al.*, 2014).

Prevention and Control of Cardio -Vascular Diseases (CVDs)

Cardiovascular diseases (CVDs) are one of the leading cause of death in the world, claiming about 17.7 million lives in 2015 and accounting for about 30% of all the global deathswith 75% reported in the developing countries (WHO, 2017). CVDs are disorders of the heart and blood vessels as a result of high BP. These may damage the endothelium of the blood vessels, thus allowing LDL-cholesterol access through the damaged site. The white blood cells are then mobilized to the site to destroy the bad cholesterol thereby forming an aggregate of platelets or plague (bump). The plague develops to block the vessels and may result into coronary heart disease (CHD) if it occurs in vessels leading to the heart thereby causing what is called heart attack. If it occurs in the vessels leading to the brain, then

stroke or paralysis may result. Peripheral arterial disease (PAD) may occur if the blockage is in the blood vessels supplying the limbs especially the legs, causing severe pain and sometimes difficulty to walk (Gauthan and Mohammed, 2009). Phytosterols can inhibit the absorption of cholesterol and also decrease the thickness of the arterial walls, as well as lowering the FA levels in the liver (Mitsuo, 2009; Niti *et al.*, 2014). Sesame seeds and oil contain phytosterols with similar structure as cholesterol, and can compete with it for the binding site for transportation and absorption (Ghazavi and Mosayevi, 2012). Gamma tocopherol which is found in abundance in sesame can also inhibit plague formation and enhance the oxidation of LDL.

Prevention and Management of Diabetes

According to the WHO, cases of diabetes rose from 108 million in 1980 to 422 million in 2014 with about 80% occuring in the developing world. By 2030, it is expected to be the 7th leading cause of death with 90% of the cases occurring in Africa (WHO, 2017). It is a metabolic disorder resulting from high glucose levels in the blood (hyperglycemia). There are 3 common types of diabetes. Type I; resulting from inadequate or no supply of insulin, a hormone responsible for glucose uptake and utilization from the blood. Type II; results from the resistance and irresponsiveness of the body cells to insulin. The Type III; gestational diabetes often associated only with pregnant women whose fat and cholesterol intakes are high before or during pregnancy (Sanker *et al*., 2011). Sesame seeds contain low carbohydrate (about 13%) with low glycemic index (GI), hence low glucose levels (Gautham and Mohammed, 2009; Svienpiper *et al*., 2009). Dietary fibers found in sesame seeds can also delay the absorption of glucose from the intestine thereby regulating its levels in the blood (Miller *et al.,* 1994).

Prevention and Control of Cancers

WHO reported in 2017 that cancer is the second leading causes of death and reported 8.8 million deaths in the year 2015. It was also observed that one in every six deaths that occur is due to cancer with about 70% of the deaths occurring in the developing countries (WHO, 2017). About 200 different types of cancer have been identified. Cancers majorly result from uncontrolled cell division and proliferation due to mutation in genes (DNA) that control and regulate cell division. Reactive free radical species can also cause damage to not only DNA but other biomolecules like PUFAs and Proteins, thereby causing cancers and other organ damages in the body (Mishra *et al.*, 2011). Sesame seeds and oil contain a lot of biomolecules such as sesamin, sesamol, sesamolin as well as vitamin E, tocopherols, phytosterols and peptides that have antioxidative activity (Wang *et al.*, 2012; Niti*et al.*, 2014). These antioxidants can scavenge the free radicals, thus preventing the damages they may cause. Myristic acid, the level of which ranges from 328 – 1728 ppm and linoleic acid (40-45% of sesame oil) have also been reported by Niti *et al.,* (2014) to prevent cancer and inhibit melanoma growth.

Regulation of Depression and Anxiety

Depression is psychiatric disorder that manifest in persistent and severe low mood, tiredness anger and shares common symptoms with anxiety (Kanu *et al,* 2010; Kumar *et al,* 2010). Insufficient serotonin has been associated with depression, anxiety and sleeplessness. High concentrations of tryptophan, an essential amino acid that is the precursor of serotonin is present in sesame. Magnesium which also occurs in high levels in sesame can also regulate the nervous system, hence reducing anxiety and depression (Kanu *et al,* 2010). Sessamol has also been reported to have beneficial roles in regulating neuro-degenerative conditions and can exert anti-depression-like effect in behavioural despair (Kumar *et al*, 2010; Punnet *et al*., 2009).

Delay of Ageing

Ageing is a process during which structural and functional changes due to oxidative stress accumulate in an organism with the passage of time (Sanker *et al*., 2011). In humans, it is the process of getting older and it has been ranked as one of the greatest risk factors of human diseases. Two third of the deaths that occur daily are age-related (Mitsuo, 2007). Ageing has been associated with the activities of free radicals that cause damage to the DNA, proteins, fatty acids and other biomolecules in the body. The process of ageing can be reduced or delayed by the activities of antioxidants, a lot which are present

in sesame lignans such as sesamin, sesamol and sesamolin together with vitamin E and other tocopherols, resulting in strong antioxidant activity. Sesamin can also inhibit the metabolic decomposition of tocopherols, hence high antioxidant activity (Sanker *et al*., 2011). Gautham and his workers (2009) have also reported that oxidative stress can also be reduced by sesame lignans by increasing the activities of antioxidative enzymes in the body.

Skin and Hair Care

Many skin disorders such as sunburns, wrinkles and even skin cancer can result from damages caused by reactive oxygen species (ROS) or radicals produced by Ultra Violet (UV) light of the sun. The natural antioxidants present in sesame seeds and its oil can act as a defensive system against ROS. Gautham and Mohammed (2009) have reported that topical application of alpha-tocopherol or sesame oil can prevent the mutation caused by irradiation, hence protection against cancer, and this was supported by Rashma *et al*. (2010). Facial application of sesame oil with turmeric powder in milk can also remove pimples and makes the face look smooth, soft and younger (AgroNigeria, 2016). A famous women body lotion called Neutrogena is made from sesame oil

Anti-Microbial Application

Results have shown various antibacterial and anti-fungal activities of sesame oil. In a study, sesame oil has been reported to compare well with a synthetic mouth wash called Chlohexidine in improving plague-induced gingivitis and also cable of inhibiting the growth of *Streptococcusmutans* involved in plague formation (Asokan *et al.,* 2009). Lyer and Narayanamunthy (1953) demonstrated the anti-microbial activities of sesamin against *Mycobacteriumtuberculosis, Staphlococchus aureus, Streptococuspyrogenes* and *Bacteriumtyphosum*. Isolated bioactive substances including naphthoquinones, Chlorosesamone and other derivatives of quinone have exhibited anti-fungal activity (Gautham and Mohammed, 2009). Preliminary studies at National Cereals Research Institute (NCRI) Nigeria, have also demonstrated the antibacterial and anti-fungal activities of black soap produced from sesame straw ash extract and sesame oil (Umar *et al*., 2008). However, further investigations are required and on-going for optimization and subsequent up-scaling of the technology. In order to increase local consumption and utilization of sesame seeds in Nigeria, there is the need for extensive information dissemination and extension services. More researches are however required for the development of new value-added products of sesame that will meet consumer preference and acceptability as well as optimizing the production parameters for subsequent up scaling production.

Conclusion

Only a few of the nutraceutical uses of sesame have been highlighted here. With its numerous health benefits, sesame seeds can be rightly regarded as “micro-capsules” and should be incorporated into daily diets especially for those suffering from ailments such as cancers, hypertension, diabetes and heart problems. Value –added sesame products is recommended. National Cereals Research Institute. Nigeria has taken long strides in developing simple adoptable household technologies for processing, oil extraction,and production of sesame milk, weaning food, soup condiments, composite flour for bread and other bakery products. More research is required for up-scaling the existing technologies and developing new products. Increase local utilization of sesame will not only improve the health status of Nigerians, but also create more jobs and increase the income of sesame farmers.

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Table 1.Top ten world producers of sesame in 2010

No	Country	Production (x 1000 tons)	(tons/hectare)
1	Myanmar (Burma)	720	0.46
2	India	620	0.34
3	China	590	1.22
4	Ethiopia	310	0.99
5	Sudan	250	0.19
6	Uganda	170	0.38
7	Nigeria	120	0.72
8	Burkina Faso	90	0.50
9	Niger	90	0.96
10	Somalia	70	0.49

Source: FAOSTAT (2013)

Table 3. The essential amino acid composition of sesame seeds and WHO requirements

EAA	sesame seeds (g/100g)	WHO requirements (g/70kg body weight)
Try	3.71	0.25
Thr	7.04	0.93
Iso	7.30	1.24
Leu	12.99	2.42
Lys	5.44	1.86
Met+cys	9.02	0.93
Phe+Tyr	16.09	1.55
Val	9.47	1.61
His	4.99	0.94

Source: WHO, (2010)

Table 2. Chemical Composition (g/100g dry weight) of sesame seeds

Chemical composition (%)	Ghandi Srivastava (2007)[a]	Nzikou (2009)[b]	Manal (2012)[c]	Shahidi (2005)[d]
Moisture	11.00	5.70	2.86	5.00
Fat	48.21	54.10	59.28	51.5
Protein	26.94	20.00	23.18	20.00
Ash	5.59	3.70	3.04	5.00
Fibre	3.90	3.20	7.31	6.00
Carbohydrate (by difference)	5.59	13.40	4.33	12.50

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Figure. 1: Map of Nigeria showing sesame producing states